that the saving in lost time, which in this case amounted to $27,000 a year is well worth while. He stated that the joint medical and dental service was able to save an average of forty hours a year for each of five thousand employees, whose average wage was fifty cents per hour, which totaled $100,000. The cost of this service was $73,000 dollars. He stated further that the medical and dental dispensaries are looked upon as a part of the plant, just as much as the sales or shipping or manufacturing departments are.

Another element of cost which is deserving of consideration is transportation and hospitalization of ambulatory cases, where local service with a reasonably short trip will accomplish equally good results. Thus one company, operating extensively in several states, finds it advisable and satisfactory to arrange for dental service in certain centers rather than transport patients long distances and hospitalize them at a central point, with a greater loss of time.

In some instances overenthusiastic individuals have expanded the dental service until it became top-heavy and collapsed of its own weight. It is difficult to reinstate such a service. It is also unwise to employ any considerable amount of clerical assistance in an effort to prove a theory in connection with the economic value of dental service.

EUROPEAN INSURANCE PLAN

The European situation is somewhat different. There the insurance plan prevails generally. It is especially true in Germany, where every person employed must be insured and in England, where the Health and Unemployment Insurance Act is very generally applied.

In Germany, with a population of sixty-five millions, eleven dental dispensaries are maintained for workers. In New York, with ten million people, fourteen or more dispensaries are in operation; in Ohio there are sixteen; in Pennsylvania, seventeen; and in Massachusetts, nineteen dispensaries.

In England between thirteen and fourteen million people belong to approved societies, which avail themselves of the benefits of the Health Insurance Act. A great many of the approved societies use their surplus funds to pay in part for additional dental benefits, the patient paying the difference in cost. It has been estimated that $50,000,000 annually will be available for about fifteen million people in 1930, and that 50 per cent of them may avail themselves of this service. All of these people are compulsory contributors to the plan, but many will not use it.

I visited some of the industrial dental clinics, and one in particular interested me. It was one of the two dispensaries maintained by the London Omnibus Employees Association; there are thirty-five thousand members in the society. Three dentists, four nurses, and four mechanics were employed there whose hours of labor and compensation were fixed by the association. The only service rendered was the necessary prophylaxis, the extracting of teeth and making of plates. The volume of work to be done and the limited means at the disposal of most English workmen necessitate that form of service which will render the greatest amount of restorative service for the least expenditure of money.

I found generally on the Continent that, because of the compulsory insurance system, the largest percentage of the people pay little or no attention to the prevention of disease or to keeping well because they know the contributory plan makes it possible for them to go to the clinic or the hospital for service whenever they are sick. Ninety per cent of the people of Germany go to public clinics for their dental service. I visited forty dental schools and equally as many community, school and industrial dental clinics in western Europe, and in nearly all of the countries which I visited little effort is being made to maintain health and efficiency by keeping well.

The industrial dental dispensary has a very definite value in any plant where there is a sufficient number of employees (three hundred or more) to justify health service. The returns justify the expenditure made both as to time saved and good will earned.

The service in dentistry is quite satisfactory if conducted on a part-time basis, if, in the selection of the dentist or the staff, care is taken to choose persons who are capable and *interested* and who will remain long enough to establish and maintain a procedure that will be satisfactory to employer, employee, and associates alike.

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PRINCIPLES WHICH GOVERN REFLEX ACTION IN DISEASE*

By F. M. Pottenger, M. D.
Monrovia

Discussion *by Samuel D. Ingham, M. D., Los Angeles; Lewis Gunther, M. D., San Francisco.*

An understanding of the principles of the visceral reflex is essential to the understanding of disease, yet no effort commensurate with its importance is made to understand the subject. Certain reflexes arising and ending in the voluntary structures are described in all textbooks, but the visceral reflexes receive very little discussion except in the writings of physiologists.

Disease expresses itself in symptoms. Symptoms are disturbances of normal physiology. A disease can rarely be suspected by the one affected until it begins to produce changes in physiologic action, such as discomfort, pain, or a disturbance in function of some organ, as the eye, heart, lungs, stomach, intestines, liver or kidney.

In order to understand the part played by the reflex in disease it is necessary to understand to what processes activity in the body is due. Activity of cells is automatic. In the viscera it exists independently of nerves and hormones, and takes place normally as long as their protein and lipoid masses are bathed in the physiologic salt-containing body fluids.

The hormones or chemical messengers are not for the purpose of causing action but of altering

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the action established by certain cells. They are more selective than the electrolytes found in normal body fluids. Apparently calcium on the one hand and sodium and potassium on the other bear a share in the activity of all cells of the body. They antagonize each other and when rightly balanced keep cellular activity within the bounds of physiologic equilibrium. The hormones on the other hand, through selective action, affect certain activities to the exclusion of others. They, however, form the chemical system for correlating activity in different parts of the body, and are thus a part of the mechanism which is provided for serving the more complex organisms.

FUNCTION OF THE NERVOUS SYSTEM

The nervous system, however, is the chief correlating and integrating system of the body, and causes a very complex organism made of many parts to function as a unit. From the central nervous system fibers go out to every muscle and gland cell in the body. The neurons going to the body cells are of two kinds: one for picking up stimuli and carrying them centralward, the other for translating stimuli into action. Every afferent neuron which carries stimuli centralward ends in the posterior root ganglion of the cord and the part which corresponds to it in the brain. From here the stimulus is carried further into the central nervous system by what are termed connector or intercalated neurons. Through these connector fibers every afferent neuron is able to join with every efferent neuron of the body. Thus is established a mechanism which is able to bring every part of the body into a close and harmonious relationship during conditions of physiologic activity; and thus is established, furthermore, a mechanism which is able to produce disharmony through reflex effects in any and every part of the body during conditions of pathologic activity.

While the body cells can function without nerves, yet their action is under the influence and control of nerves. There is a difference in the nerves supplying different structures. Thus we have the voluntary nerves supplying the skeletal structures and the involuntary or vegetative nerves supplying the visceral structures. The latter supply all smooth muscles and secreting cells, and in supplying the blood vessels go to every part of the body. The vegetative system is shown in Fig. 1.

There is a free and intimate communication between the various neurons of the voluntary system with each other, and the various neurons of the vegetative system with each other, and the various neurons of the voluntary system with the various neurons of the vegetative system, which binds together visceral and skeletal structures in such a way that action under either physiologic or pathologic conditions in one organ or structure of the body may influence other organs or structures through reflex action.

Whenever disease exists in the body it alters function in few or many structures. It may produce its effects in several different ways. It may be an infection producing bacterial toxins. It may exert a destructive action on certain tissues and cause toxins to be liberated from them. It

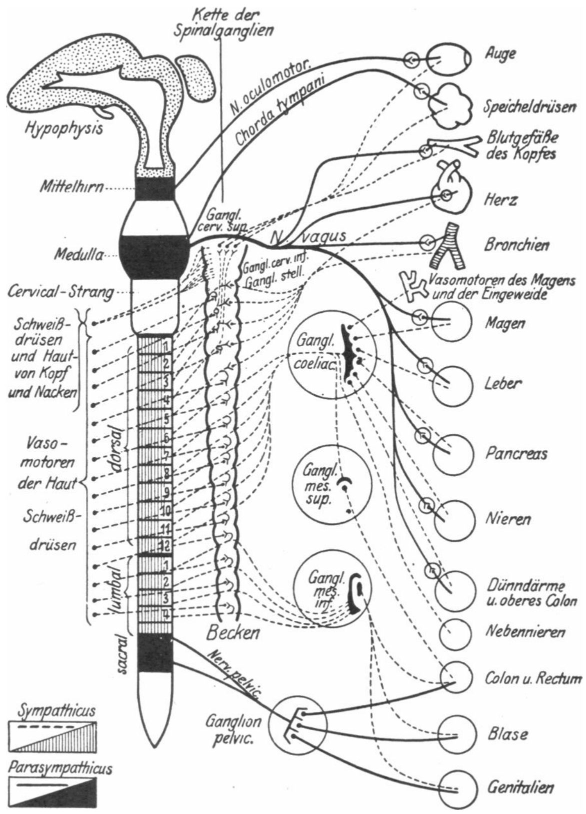

Fig. 1. Schematic Illustration of the Distribution of the Two Components of the Vegetative Nervous System, Showing Its Division into Sympathetic and Parasympathetic and Their Branches to the Various Organs.—The thoracolumbar portion of the cord, which gives origin to the sympathetic nervous system, is represented by lines. The portions of the midbrain and medulla, and sacral segments of the cord, which give origin to the parasympathetic system, are represented in black. The peripheral nerves belonging to the parasympathetics, are shown as solid black lines, while those belonging to the sympathetic system are shown as broken lines. This chart shows the double innervation of the structures of the head, heart, and the entire enteral system, and likewise indicates the single innervation for the blood vessels, pilomotor muscles and sweat glands of the body. (Symptoms of Visceral Disease.)

may interfere with the action of some important organ so that it fails to do its work and allows a retention of poisonous products to circulate in the body fluids. It may exert an injurious effect locally because of its assuming an inflammatory nature. Lastly, it may disturb function in other viscera reflexly.

We must attempt to find out in what way function is disturbed as a result of the above mentioned harmful influences. We assume that toxins which circulate generally produce harmful effects on the cells throughout the body. This affects to a varying degree the automaticity of the cells themselves and further affects them in the aggregate as found in definite structures and organs. Thus we assume that higher centers in the central nervous system, the nerves themselves, as well as glands, muscles and other peripheral structures, come in for injury from toxins.

Through their effects on ganglia in the central nervous system toxins produce harmful stimuli which are sent peripheralward, where they produce dysfunction. This is evident in cases of general toxemia where the equilibrium of the entire vegetative system is disturbed. The chief peripheral effect, however, is that of an oversympathetic stimulation. The reflex is most evident in disease caused by definite organic inflammation. In such instances the inflammatory process causes stimulation of the sensory neurons whose receptors are found in the tissues affected by the pathologic process, beyond the degree of stimulation which is usual for that organ or tissue in health. These excessive stimuli cause impulses to be carried centralward and to be transmitted to efferent neurons which translate them into action often excessive in other structures.

This excessive action is represented as symptoms of disease. It may be a pain, or changes in distribution of blood, or a muscle contracture, or disturbed secretion in some gland. The reflex activity may affect only one organ or it may extend widely according to laws which we shall discuss later.

There are several groups of reflex symptoms possible in the presence of disease, such as: (1) from one part of the voluntary system to another part of the same system, as is met in inflammation of a joint; (2) from the voluntary system to the vegetative system, the principle of which is utilized when heat or blisters are applied to the surface of the skin in order to influence internal organs; (3) from the vegetative system to the voluntary system, as is illustrated by the muscle spasm in skeletal muscle in the presence of visceral inflammation; and (4) from the vegetative system to the vegetative system, as is witnessed so often in visceral inflammation and is especially well known in the so-called functional symptoms which affect one part of the gastro-intestinal canal when another part or a neighboring organ is the seat of inflammation.

TYPES OF REFLEXES MET CLINICALLY

Reflexes commonly met in clinical practice are: (1) the *motor reflex* in case of visceral disease, such as the spasm of the muscles of the abdomen in appendicitis, gall-bladder disease, and ulcer of the stomach; of the muscles of the shoulder girdle and diaphragm in tuberculosis of the lung; of the intercostals in pleurisy; and of the lumbar muscles when the kidney is inflamed as in tuberculosis of that organ; (2) the *sensory reflex* or pain which is referred to the surface of the body when important viscera such as the appendix, gall bladder, stomach, pancreas, urinary bladder, kidney, ureter, heart, lungs, and pleura are inflamed (this is not a true reflex, physiologically, but may be so classed clinically); (3) the *trophic reflex,* which shows as a degeneration of tissue when nerves have long been irritated by excessive stimuli, such as is best illustrated by the atrophy which takes place in the muscles and skin and subcutaneous tissue innervated by those cervical nerves which express reflexly the stimuli arising in the lung in chronic pulmonary tuberculosis; and (4) the *motor* and *secretory reflexes,* which are usually spoken of as functional symptoms for which the stimuli arise in one organ and are expressed in another, such as the motor and secretory changes in the gastro-intestinal canal caused by inflammation of the appendix, gall bladder, stomach (ulcer), lungs, heart, kidney, and genito-urinary organs, or the asthma resulting from nasal irritation and the cardiospasm and pylorospasm which result from various visceral irritations.

NATURE OF REFLEXES

Reflexes may be comparatively simple or very complex. While a reflex requires only three components: a sensory receptor to pick up the stimulus, a motor effector to translate the stimulus into energy, and a synapse, where the stimulus is transferred from receptor to effector, yet such a simple arrangement is probably never found. There are usually several and more often many neurons interposed between the receiving and affecting nerve. Therefore reflexes are, as a rule, quite complex.

The complexity of reflex action is provided for by the multiplicity of connector neurons in the central nervous system as previously mentioned, which connect the incoming nerve bearing the stimulus with all motor nerves of the body. This widespread connection is seen in strychnia poisoning where the resistance at the synapses is broken down and universal contraction of muscles may be reflexly affected from irritating any afferent neuron.

While widespread efferent paths are open to all stimuli, yet most reflexes arising in definite tissues and organs are expressed in certain other definite areas according to a well-established law, and when a departure from this regular course takes place it, too, follows definite laws, which will be discussed later.

Segmental Nature of Reflexes.—In order to understand visceral reflexes we must acquaint ourselves with the embryologic development of the body, for here alone can we acquire a comprehension of the segmental relationships which are fundamental to understanding the reason why action in a given tissue or organ, or a definite skeletal area, is expressed as a result of impulses arising in other definite tissues or organs. It is quite easy to understand the segmental relationships of such organs as the heart and stomach in prevertebrate life where underlying viscera and overlying skeletal structures are innervated by nerves from a corresponding cord segment, as may be inferred from Fig 2, in which each segment is complete in itself; but to understand the relationships of the viscera in the thorax and abdomen through the cranial nerves to the somatic structures of the head is not so obvious; yet it follows the same segmental law of body development.

In vertebrates segmentation for striated and unstriated muscle, as the relationship is shown

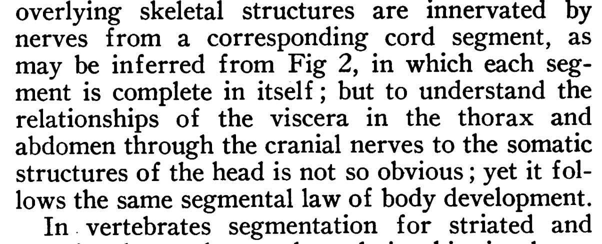

Fig. 2.—Diagrammatic representation of a primitive vertebrate animal—the amphioxus divided for convenience into three segments for the head, seven for the neck, twelve for the thorax, nine for the lumbosacral region, and an indefinite number for the coccygeal region. For clearness of comparison the heart (H) is represented as occupying the same position as in man, so that an adequate stimulus from the heart would cause pain in the distribution of the four upper thoracic nerves covering and protecting the heart. (Ross and Mackenzie.)

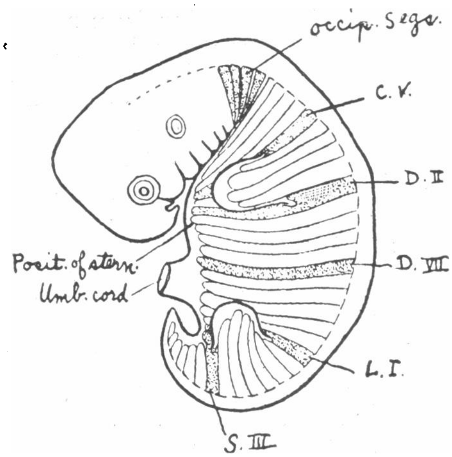

Fig. 3.—Diagram of a human embryo, fifth week, showing the arrangement and extension of the mesoblastic segments. The first and last of each segment entering into the formation of the limbs is stippled (C. V. and D. II, and L. I. and S. III). The position is indicated in which the sternum is formed. (A. M. Patterson.)

through spinal and sympathetic neurons, is evident throughout the entire length of the body. The lateral ganglia send connector fibers segmentally to the smooth dermal muscles just as the anterior roots supply the striated muscles of the body. Furthermore, connector fibers pass peripherally to visceral musculature through definite ganglia, thus connecting them segmentally with the somatic segments. The segmental relationship in man may be seen best in the embryo, as illustrated in Fig. 3.

The segmental relationship between the somatic and endodermal musculature in the vertebrates, as the relationship is shown through the cranial and parasympathetic neurons, however, is just as regular. The endodermal musculature was derived from the appendicular unstriated musculature of the invertebrate which was closely related segmentally to the head and face muscles. Thus in evolution, vagus innervation, which was related to definite somatic head and face segments in the invertebrate was carried as far as the colon as it developed into the digestive tube of the vertebrate.

So we must understand the striated skeletal musculature, the smooth dermal musculature and the visceral musculature, all as being related segmentally in such a manner that the relationships in the more primitive organisms are preserved in the vertebrate.

Reflexes are primarily segmental because the neuron connections of tissues belonging to the same segment are most closely connected. From a clinical standpoint this is extremely important, for it points the way for interpreting reactions which accompany disease.

One can interpret the origin and expression of reflexes only as one understands the manner in which the body has developed from more simple segmental organisms; and can understand them only by possessing a knowledge of the physiologic laws which govern reflex action.

THE LAWS OF REFLEXES

The Law of the Minimal Stimulus.—Sensory end organs in tissues are being subjected to stimulation more or less constantly; but they withstand a certain strength of stimulus before they pick it up and carry it centralward. All stimuli which are insufficient to effect the sensory receptor are called *subminimal*. The one which is just sufficient to effect it is called the *minimal stimulus*. Subminimal stimuli, if repeated in sufficiently rapid succession, are raised to minimal or even above, and cause impulses to be carried to the higher centers.

Each tissue or organ develops sense organs capable of picking up the particular type of sensory stimuli to which that tissue or organ is subjected. The somatic receptors are thus able to pick up and translate into its proper sensory manifestation such forces as heat, cold, light, sound, pinching, cutting and pressure, because the skin naturally comes in contact with all such forces and must develop the sensory end organs for them as a matter of defense. The internal viscera, on the other hand, do not meet conditions which require the development of many types of sensory receptors. The viscera normally never come in contact with such forces as heat, cold, light, sound, pinching and cutting, consequently have no sensory apparatus to pick up this type of stimulus. In order to carry impulses centralward the particular receptor found in an organ must be excited by the particular stimulus which it is designed to convey, and the stimulus must be at least minimal in strength. The term *adequate stimulus* is used to designate that the stimulus is of a quality to excite action. A stimulus cannot produce reflex action unless it be both *adequate* and at least *minimal*.

Sherrington's Law of Segmental Proximity.—Sherrington enunciated a law which governs the production of spinal reflexes as follows:

"Broadly speaking *the degree of reflex spinal intimacy between afferent and efferent spinal roots varies directly as their segmental proximity.*"

And then, by way of making the law more explicit, he says:

"Taken generally, *for each afferent root there exists in immediate proximity to its own place of entrance in the cord, e. g., in its own segment a reflex motor path of as low a threshold and of as high potency as any open to it anywhere.*"

I have suggested that in order to make this law complete it should be understood that this relationship of afferent and efferent neurons in the cord preserves developmental relationships; then it will apply to all viscera, including the lung which otherwise would be an exception, since its skeletal reflexes take place through cervical nerves (the union being completed by intercalated neurons), although the afferent impulses enter the cord through the upper five or six thoracic segments.

The somatic segmental nerves in which reflexes from the principal organs are expressed, according to Sherrington's law, may be inferred from Fig. 4, in which their sympathetic innervation is shown.

Law Governing the Spread of Reflexes.—When a stimulus is sufficient to discharge reflex activity over certain efferent neurons it produces as much activity in the skeletal muscle fibers innervated by those particular neurons as though the

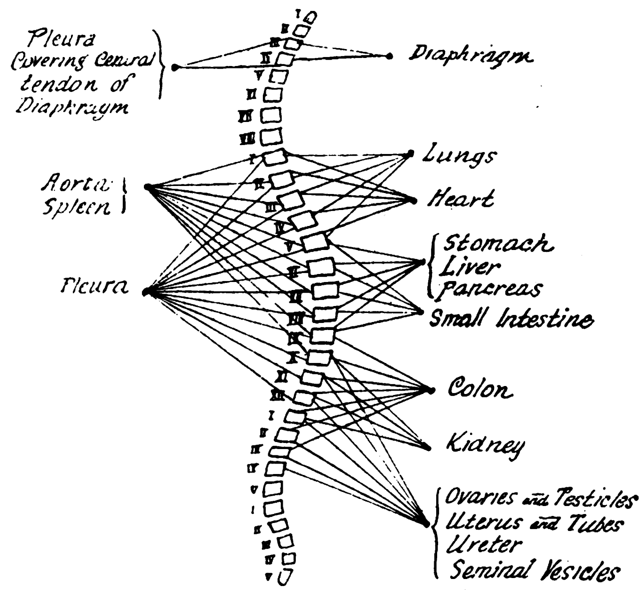

Fig. 4.—The connector neurons for the important thoracic abdominal, and pelvic viscera.
In the figure the connecting neurons are those which belong to the thoracolumbar outflow; except those going to the diaphragm, which are spinal nerves (phrenics). The motor cells for the viscera are found in the various collateral ganglia.
The figure shows that the innervation of the various viscera may be divided into groups. The heart and lungs are innervated from practically the same segments, the upper Ist to VIth thoracic. The stomach, liver, and pancreas from the same segments, Vth to IXth thoracic. The colon, kidney, and pelvic viscera from practically the same segments, IXth and Xth thoracic to IIIrd and IVth lumbar.
In spite of this grouping in innervation, each organ is brought in reflex connection with efferent neurons, both sensory and motor, which are more or less definite, in such a way that the motor and sensory reflexes do not overlap as much as might be indicated. (Symptoms of Visceral Disease.)

stimulus were many times stronger, according to the "all or none" law of activity. That is, when a muscle fiber contracts it produces a maximal contraction. A stronger stimulus cannot make its contraction stronger, but can express itself only by causing activity in more muscle fibers.

The corollary to this muscular action is that a minimal stimulus affects a minimal number of efferent nerve fibers, while a maximal stimulus spreads to many, thus widening the extent of the reflex.

VISCERAL PAIN

Visceral pain in a physiologic sense is not a reflex, but from the clinical standpoint we may be allowed to discuss it as such.

Most confusing to students is the fact that the source of sharp visceral pain is not in the organs affected; but such is true, as may be readily seen in the pain in the arm caused by angina, and pain in the epigastric region in ulcer of the stomach, whether the stomach has a high position as in individuals of sthenic build or is found at the pelvic brim, as in individuals of hyposthenic build, as pointed out years ago by Mackenzie.

There is a feeling of pressure or distention, and one of contraction, in such viscera as the stomach and intestines, that may be noted and found directly in the organ, according to Head. But a true sharp pain cannot be expressed by the sensory receptors of viscera which have never come in contact with or developed a sensory organ for detecting such sensations.

Head has announced the following law governing visceral, or *referred pain:*

"When a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility, the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility, to which the stimulus was actually applied."

It should further be noted that the projection of *referred pain* follows the same laws of the segmentation of the body as is followed by the visceromotor reflex.

In harmony with the preceding discussion, it can be seen that the visceral nerves must be very active in conditions of disease. They are disturbed by all toxemias, and they are irritated whenever a tissue or organ is inflamed. If the stimulation is sufficient it is followed by action in some or many other tissues and organs. Such action is abnormal although it follows the usual nerve paths. It is recognized as a part of the symptom-complex of the particular disease in question.

The best preparation for appreciating visceral reflexes is an understanding of the vegetative nerves, and the laws which govern reflex action. There are certain reflex disturbances in organs which can be produced by stimuli coming from many sources. Instances are cardiospasm and pylorospasm, which may be caused by stimuli from many organs such as the lung, gall bladder, appendix, stomach and intestines, urinary bladder, kidney or generative organs. The stimuli from the different organs here mentioned will enter the cord at all levels from the first dorsal to the upper two or three lumbar segments, but no matter where they enter, before mediation with motor neurons occurs, the impulses will be carried to that part of the cord, thoracic segments five to ten, from which the nerves supplying the pyloric and cardiac sphincters arise.

The fact that stimuli arising in so many organs can cause disturbed function in a single organ, and stimuli from a single organ can cause reflexes in so many organs, is very confusing in itself, but there are always other symptoms, very often other reflexes, which will help to indicate the organ which is diseased. Every important organ has through its afferent sympathetic nerves and their connection in the cord with spinal nerves particular areas for expressing reflexes in the skeletal structures, which are fairly definite, because they follow the laws of segmental relationship.

In my book on symptoms of visceral disease I enunciated the following law as governing the subject of visceral reflexes expressed in skeletal structures:[1]

"Every important internal viscus is so connected in the central nervous system that it is able to produce reflexes through afferent sympathetic and efferent spinal nerves, with definite skeletal structures; and, if acutely inflamed, should show motor reflexes and altered sensation (pain), and if chronically inflamed, trophic changes. Therefore, spasm of muscles, altered cutaneous sensation, and degeneration of muscles, subcutaneous tissue and skin, in areas having definite limited segmental innervation become important diagnostic phenomena."

While the laws herein discussed as governing reflexes hold in most instances, yet reflexes sometimes fail to follow such laws. Fortunately we have learned some of the important reasons for such failure. We find causes at every physiologic level of the individual. The first cause may be in the cell itself. The electrolytes in the cell may not be present in proper proportion. It has been shown in the experimental heart, for example, that if calcium is in excess in the cell, stimulation of the sympathetic nerves may cause inhibition instead of acceleration.

Again the relative acidity of the tissues makes a difference in nerve reaction and might make uncertainty in reflex action.

Different hormones produce selective action on certain body cells, and when greatly in excess or markedly deficient might throw these cells into disharmony, which in turn might be reflected in any reflex action which was to be expressed in these tissues.

The nerves themselves become hypersensitive at times, their threshold of response becomes lowered and action takes place as a result of what under ordinary conditions would be *subminimal stimulation*. This is often met in clinical practice. We see it particularly in the toxemias of various kinds and in nerves which have been subject to prolonged stimulation, as occurs in such chronic conditions as pleurisy, pulmonary tuberculosis, pelvic troubles, and chronic kidney inflammation. The neurons connected with these organs become so easily affected, that is, their threshold of response becomes so lowered, that pain or discomfort is shown whenever any marked physiologic adaptation is required of the patient. Under conditions of tiring, worry, changes in weather, or other disease, the neurons connected with the particular, injured organ, respond with pain or discomfort, while sensory neurons from other structures react normally; so that, as far as they are concerned, the individual is entirely unaware of the extra load.

Last but not least, reflexes are altered by emotions. Through such harmful emotions as fear, anger, worry, disappointment, discontent, and unhappiness nerve reaction becomes altered, and this manifests itself in changes in the reflexes which are brought about by disease. In the presence of such emotions, reflex action is often exaggerated. We see this in the various disturbances of function in internal viscera and the exaggeration of referred pain.

If man were a machine instead of a thinking, emotional, physiologic and pathologic human being, our problems would be more like test-tube reactions, more certain but less interesting. It is the quest for the hidden, the concealed, the desire to understand the vagaries in man's reactions that make the study of medicine so interesting and so worth while. With a knowledge of the vegetative nervous system, an understanding of the physiologic action of the body cell, an acquaintanceship with the laws of the reflexes, and the factors which act to prevent reflex activity from following these laws, we have at our hand the key to the solution of many of our diagnostic and therapeutic problems.

Monrovia.

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DISCUSSION

Samuel D. Ingham, M. D. (1252 (Roosevelt Building, Los Angeles).—It is axiomatic that a knowledge of physiology is necessary for the interpretation of symptoms of disease. That Doctor Pottenger fully appreciates this, is demonstrated in his discussion of reflexes in the physiologic sense. Carried to a logical conclusion, practically all physiologic activities of the human organism may be considered as reflexes of more or less complicated patterns. It is interesting and important to consider how numerous and accurate are the self-regulating mechanisms which maintain equilibrium within normal limits in all of the vegetative processes of the organism; for instance, the bodily temperature, respiratory exchanges of gases, nutritional and metabolic balances, blood pressure and circulatory functions, internal glandular secretions and innumerable other mechanisms are automatically maintained within the limits of what we call normality. Each and all of these processes may be considered to be regulated through the agency of reflex activity.

It might fairly be said that all symptoms of disease may be read largely in terms of disturbed reflex activity. What seems to have escaped general recognition is that the reflexes manifested through the vegetative nervous system are as definite and as important as those manifested through the so-called cerebrospinal system. For interpretation a knowledge of anatomy and physiology is necessary, at least as regards basic considerations. Based upon the theory of evolution, we have come to consider that all spontaneous activities of the animal organism are essentially utilitarian in their nature, so that symptoms of disease are only variations of normal activities; so any bodily reflex may be hyperactive, normal, subnormal or absent, and clinical experience is necessary for its proper interpretation.

One field of the subject that Doctor Pottenger barely touched is that of reflexes which are dependent upon emotional activities, the disturbance of which have far-reaching consequences. Every emotional state has as a component part a definite, characteristic physical reaction pattern which is distributed through the efferent portion of the vegetative nervous system. Each reaction pattern, therefore, is in itself a reflex action. An unstable emotional equilibrium, while primarily acting or tending to act in a beneficial way in respect to the cause of the emotion, may be harmful in respect to the circulation, glandular activity or other important functions. In the presence of prolonged disturbance of the emotional reactions in an individual, the sensitization and conditioning of reflexes act to produce more or less permanent functional changes and establish unfavorable visceral habits. The clinical picture of neurasthenia may be interpreted largely in terms of such reactions.

The subject of Doctor Pottenger's paper is so large and so important that he might write a book as a supplement to his very excellent paper.

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Lewis Gunther, M. D. (University of California Medical School, San Francisco).—The importance of the segmental arrangement of the central nervous system cannot be overemphasized. Since visceral symptoms are transferred to the periphery over the spinal nerve roots, it is obvious that an understanding of visceral pain presupposes a knowledge of the visceral reflex arc over which such transference takes place. Doctor Pottenger has amply supplied us with information regarding the nature of these reflexes, and the spinal nerve roots that take part in the reflex, in this paper, and in his book on the symptoms of visceral disease. It also stands to reason that a working knowledge of the nerve-root topography must be possessed by the practitioner and student of medicine who desires to interpret pain.

In the interpretation of symptoms, cutaneous pain is a leading symptom. It may have its origin commonly at three sites, viz., in the peripheral nerve, in the nerve root, or in an internal organ. Medical students, as a rule, familiarize themselves with the outstanding examples of the visceral sensory reflex, more commonly spoken of as referred pain, in such conditions as gall-bladder disease, angina pectoris, and acute appendicitis. Of the three possible sites of origin of cutaneous pain, the nerve root has received the least attention. Since the sensory visceral reflex utilizes the posterior nerve roots for the transference of pain originating in an organ but appreciated at the periphery, the differentiation of symptoms having their origin in the nerve roots from those due to the sensory visceral reflex then becomes very important.

The visceral reflex has become a tool of utmost value to the medical profession, and for surgeons in particular. Just as the earlier failure to recognize the visceral reflex has led to wrong diagnoses, the present, fairly widespread lack of appreciation that cutaneous pain may have its origin in the peripheral component of the visceral arc, namely, the nerve root itself, has also led to unnecessary error in surgical diagnosis and procedure.

The hyperesthetic areas of Mackenzie, and the zone areas of hyperalgesia described by Head, associated with visceral disease, in very few instances occupy the entire area of distribution of the particular nerve roots which are included in the reflex arc. Examples might be cited such as the right lower quadrant sensory disturbances found in acute appendicitis where the maximum pain and tenderness is generally in the region of McBurney's point, the remainder of the tenth, eleventh and twelfth dorsal roots posteriorly being uninvolved; the right upper quadrant pain in acute cholelithiasis and cholecystitis, where the maximum disturbance may be over the topographical region of the gall bladder, at the end of the tenth rib, or at the angle of the scapulae, all of these points lying within the distribution of the sixth to ninth or tenth dorsal roots, but the major part of the distribution of these roots remaining unaffected; the pain of gastric ulcer which, although referred over the same roots as the former, is maximum in the mid-epigastrium. This is in contrast to the disturbances met with when the pathology has its origin in the nerve root itself. Objective and subjective sensory alterations in the latter usually involve the entire distribution of the root and are not infrequently bilateral.

Doctor Pottenger has pointed out that long standing pathology in a viscus allows subminimal stimuli to become effective, which ordinarily would not be brought into consciousness. This again is in contrast to nerve-root pathology, for a long-standing process in the latter, due to nerve degeneration decreases the conductivity of the nerve, and an adequate stimulus becomes inadequate. Cope has pointed out that the objective sensory alterations in the visceral sensory reflex consist of cutaneous hyperesthesia, as well as hyperalgesia. These sensory changes usually consist of alterations in light touch as demonstrated with the cotton tuft or a very light stroke with the pin point. Similar sensory disturbances may be found generally during the first five years of nerve-root involvement incident to a spinal osteoarthritis, and in early involvement of the spinal roots in other diseases of the spine. However, in either instance, the prolonged disturbance in the spinal nerve root ultimately results in a *decrease in objective sensibility.* In osteoarthritis the decrease rarely affects more than light touch as demonstrated with the cotton tuft, whereas in other diseases of the spine hypesthesia and anesthesia to all types of epicritic cutaneous sensation will occur. In all instances the alteration in sensation involves the *entire nerve-root distribution.*

Diffuse pain, lying in the distribution of many roots, or marked sensory changes, especially a decrease in sensation, should stimulate a search for pathology outside of the viscera. Errors in diagnosis can only be avoided if the existence of cutaneous sensory disturbances, referred from pathology in the nerve root itself, is considered in the differential diagnosis of pain transferred to the periphery over the visceral reflex arc.

Doctor Pottenger (closing).—In the discussion of this paper Doctor Ingham has well emphasized reflexes due to emotional activities. I have endeavored to emphasize this on many occasions. During the past fifty years medicine has thought too much in terms of structure. Physiologic balance may be disturbed just as much by emotional as by physical stimuli. Emotional reflexes make up a large part of the picture that we are dealing with in clinical medicine. He also emphasizes rightly the reflex nature of all physiological and pathological action.

Among other things Doctor Gunther makes an important distinction between the hyperesthetic and the hyperalgesic areas, as a result of visceral disease and the pain due to disease of nerve roots. The former may occupy only a part of the area supplied by a given nerve, the remaining portions being uninvolved. We see this constantly in reflexes from the viscera. The reflex relationship involves individual fibers rather than the nerve as a whole, while nerve-root disease involves the entire distribution of the given nerve.

The nature and laws of reflexes demand careful study on the part of medical men, because action in all parts of the body is correlated and integrated through the nerves and is subject to reflex effects.

In this paper I have endeavored to bring forth principles underlying the reflex, believing that if they are better understood, clinical symptomatology will be simplified.

TREATMENT OF MALIGNANT TUMORS OF THE BLADDER, WITH SPECIAL REFERENCE TO SURGICAL DIATHERMY*

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Surgical diathermy is a term used to designate the coagulation and consequent destruction of tissue by means of a bipolar high frequency current. The heat is generated within the tissues because of the resistance offered by them. The degree of heat and depth of penetration are regulated by the amount of current in milliamperes, the length of time applied, the size of the electrode, the relative resistance of the different tissues between the electrodes, the loss of heat by radiation, and the loss of heat through the circulating blood. The highest temperature is at the point of contact of the smaller or active electrode with the tissues.

Tesla and d'Arsonval in 1891 found that heat was produced when the body was transversed by a high frequency current. D'Arsonval began the use of this current in the treatment of disease in 1898. Doyen advocated the destruction of tumors by electrocoagulation in 1907. Nagelschmidt coined the word "diathermy" in 1908. Corbus [1] states, however, that Kolischer of Chicago demonstrated the first patient suffering from a bladder neoplasm treated by diathermy in 1901. The former in association with O'Conor has used

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